Bedrock Geology of Davenport East and Milan Quadrangles
Rock Island County, Illinois

Prairie Research Institute
ILLINOIS STATE GEOLOGICAL SURVEY

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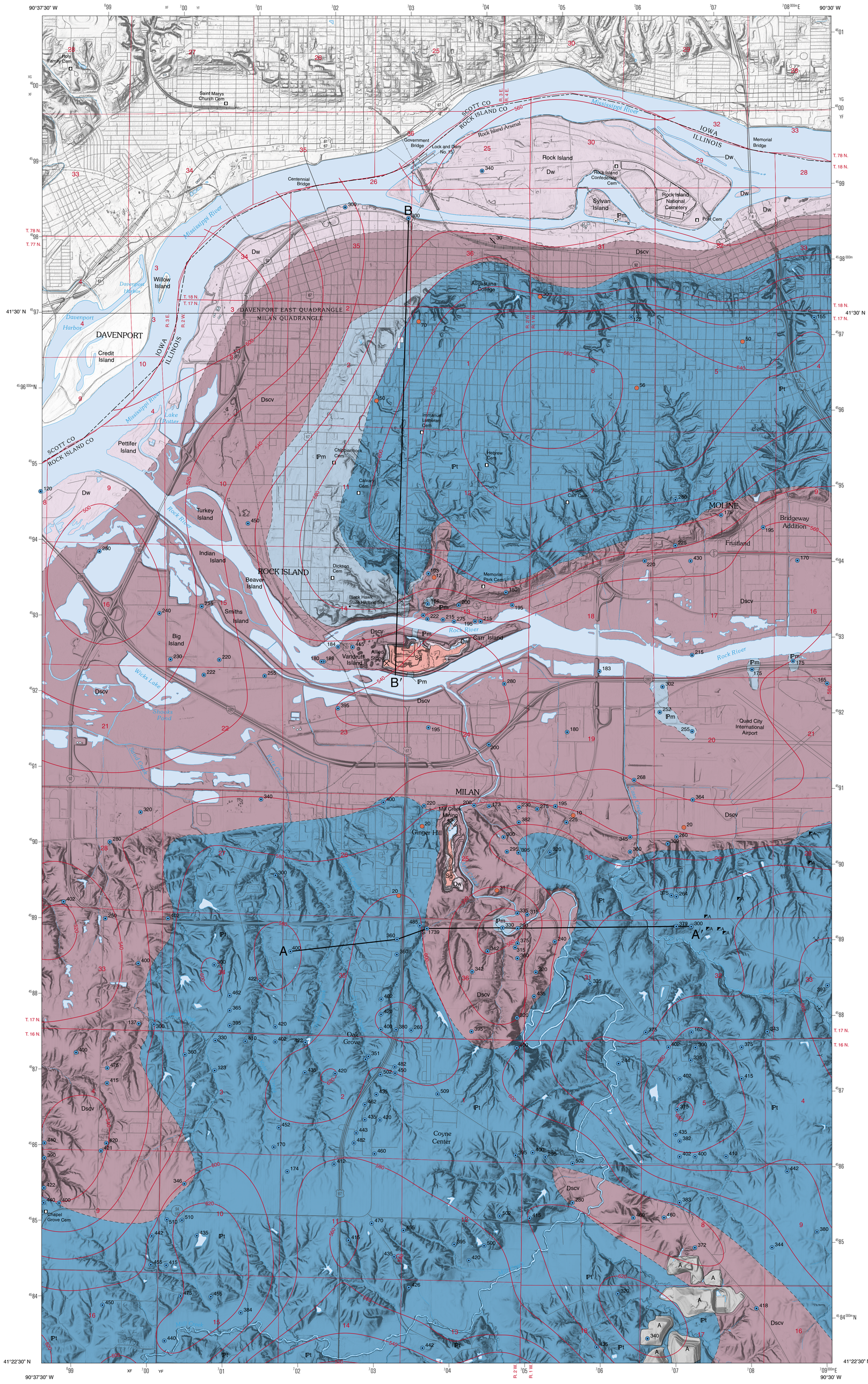
2020

STATEMAP Davenport East-Milan-BG



System	EXPLANATION	Series
	A — Altered by landfill	
	Unconformity	
Pennsylvanian	Pt — Tradewater Formation	Desmoinesian
	Unconformity	
Pennsylvanian	Pm — Muscatine Formation (New) "Caseyville"	Morrowan
	Unconformity	
Devonian	Dscv — Sweetland Creek and Cedar Valley Limestone	Upper and Middle Devonian
	Unconformity	
Devonian	Dw — Wapsipinicon Limestone	Upper and Middle Devonian
	Unconformity	
Silurian	Sg — Gower Formation	Niagaran

Point Symbols

- Coal mine shaft - abandoned
- Coal mine slope - abandoned
- Coal mine drift - abandoned
- Quarry - active
- Quarry or Coal mine pit - abandoned
- Sinkhole

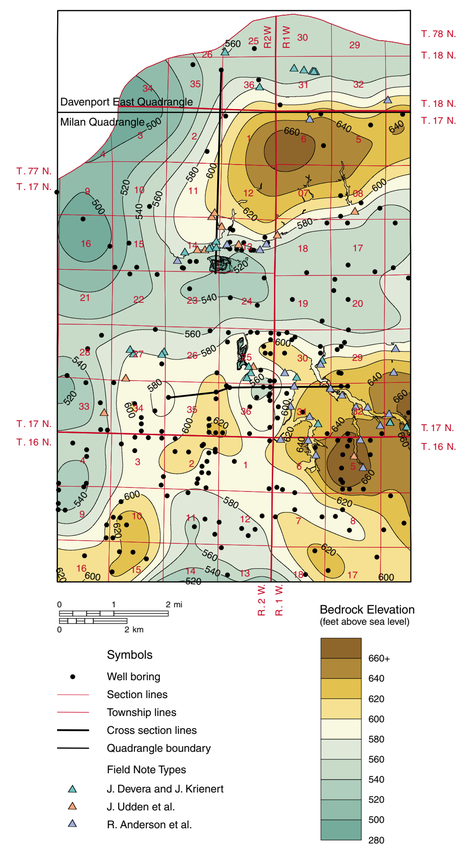
Drill Holes
from which subsurface data was obtained

- Engineering boring
- Monitoring water well
- Water well, dot indicates boring is to bedrock
- Numeric labels indicate total depth of boring in feet. Labels indicate samples (S).

Line Symbols

- Geologic contact
- Inferred geologic contact
- Elevation of top of bedrock, contour interval 20 feet
- A——A′ Line of cross section

Note: Well and boring records are on file at the ISGS Geological Records Unit and are available online from the ISGS website.



Bedrock Elevation
(feet above sea level)
660+
640
620
600
580
560
540
520
500
280

Symbols
- Well boring
- Section lines
- Township lines
- Cross section lines
- Quadrangle boundary

Field Note Types
- J. Devera and J. Krienert
- J. Udden et al.
- R. Anderson et al.

Figure 1 Map showing the intersection of bedrock topography and surface topography (derived from lidar) in the Davenport East and Milan Quadrangles. Detailed contours show potential subcrops within 20 feet of the land surface. Map scale is 1:100,000.

Base map compiled by Illinois State Geological Survey from digital data (2018 US Topo) provided by the United States Geological Survey. Shaded relief derived from LiDAR elevation data from the Mississippi River North (2011) and Rock Island County (2009) collections.

North American Datum of 1983 (NAD 83)
Projection: Transverse Mercator
1,000-meter ticks: Universal Transverse Mercator grid system, zone 15

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SCALE 1:24,000
1 1/2 0 1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 .5 0 1 KILOMETER

Geology based on field work by J. Devera and J. Krienert, 2019–2020.

Digital cartography by E.G. Bunse and J. Krienert, Illinois State Geological Survey.

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This map has not undergone the formal Illinois Geologic Quadrangle map review process. Whether or when this map will be formally reviewed and published depends on the resources and priorities of the ISGS.

The Illinois State Geological Survey and the University of Illinois make no guarantee, expressed or implied, regarding the correctness of the interpretations presented in this document and accept no liability for the consequences of decisions made by others on the basis of the information presented here. The geologic interpretations are based on data that may vary with respect to the accuracy of geographic location, the type and quantity of data available at each location, and the scientific and technical qualifications of the data sources. Maps or cross sections in this document are not meant to be enlarged.

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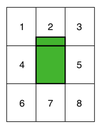
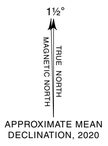


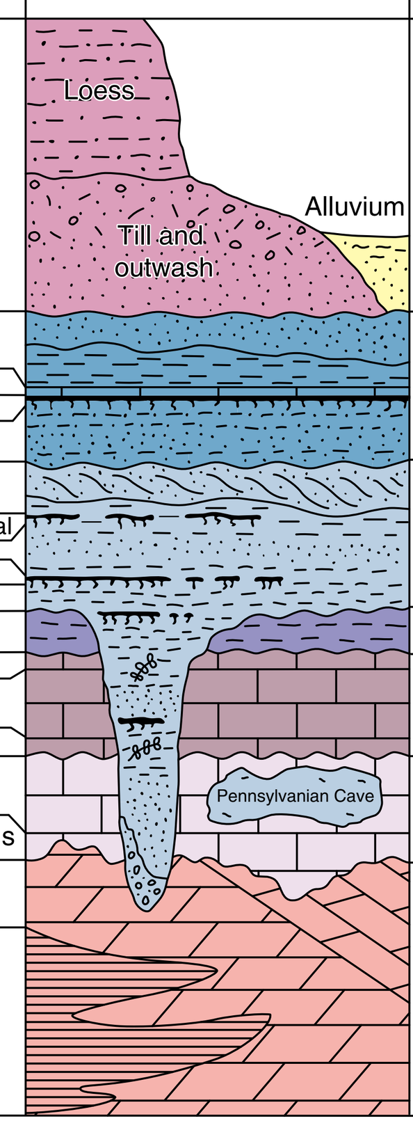
ADJOINING QUADRANGLES
1 Davenport West
2 Davenport East
3 Silvis
4 Andalusia
5 Coal Valley
6 Reynolds
7 Matherville
8 Orion



APPROXIMATE MEAN DECLINATION, 2020

ROAD CLASSIFICATION
Interstate Route — State Route
U.S. Route — Local road

SYSTEM	SERIES (Mid Continent)	GROUP	FORMATION	MEMBER or BED	THICKNESS (FEET)	UNIT
QUATERNARY	Holocene and Pleistocene		Cahokia (alluvium)		0–200	A
			Pleistocene (Till, outwash, loess)			
PENNSYLVANIAN	Desmoin-esian	Raccoon Creek	Tradewater	Seville Ls	80–100	B
	Atokan			Rock Island Coal		
	Morrowan		Muscatine (New) "Caseyville"	Wyoming Hill Coal	0–95	C
				Wildcat Den Coal		
	UD*	NA*	Sweetland Creek		0–44	D
DEVONIAN	Middle Devonian		Cedar Valley	Coralville	61	E
				Rapid		
				Solon		
			Wapsipinicon	Pinicon Ridge	65	F
				Bertram and Otis		
SILURIAN	Upper Silurian		Gower	LeClaire	100–150	G
				Anamosa		



A Surficial Deposits Loess, diamicton and alluvium, loess is composed of silt and clay yellowish to tan, contains gastropods, calcareous, in the lower part sandy. The diamicton is gray-reddish-brown, clay with silt, sand and pebbles. It also contains irregular sandy beds, wood fragments, igneous and metamorphic glacial erratics. The base of the diamicton contains a conglomerate with well-rounded igneous, metamorphic and locally derived limestone or chert pebbles and occasional boulders. Contact of the diamicton with either siliciclastics of the Pennsylvanian or limestones of the Middle Devonian.

B Tradewater Formation Sandstone, siltstone, shale, coal and limestone; sandstone is tan, poorly sorted, sublitharenite to quartz arenite, argillaceous and highly micaceous. This sandstone is angular to sub-angular containing minor amounts of feldspar and rock fragments. It varies from thin to thick bedded and is commonly cross bedded. The siltstone can be burrowed and highly carbonaceous. Some of the siltstone facies are marine as they contain marine ichnofacies including ichnospecies: *Teichichnus*, *Asterosoma* and *Conostichus*. Shale ranges from non-fissile gray to fissile black and associated with coals in this unit. One coal the Rock Island Coal Bed is widespread in the region with variable thickness. It can occur with the overlying limestone called the Seville Limestone which is basal Desmoinsian. The Seville Limestone is an argillaceous lime-mudstone that can have red and orange iron staining, fresh samples are typically medium to dark gray, containing crinoid columnals. Quarries in Rock Island County have reported thicknesses of 16' (4.9 m). Typically the Seville Limestone is about 4' (1.2 m) the thicker reported areas are confined to paleo-channels seen in the highwall of some quarries. Thin beds of chert also occur above the Rock Island Coal in gray to dark gray shale. The chert varies from bluish-gray to white and occurs with a calcareous shale. The chert has been named the "Moline" Chert by archeologists. This formation is unconformable with the underlying unit. It can occur in paleo-karst or ancient sinkholes in the Middle Devonian units.

C Muscatine Formation (Caseyville) Sandstone, shale and coal; the sandstone is white to light gray and stained brown, yellow and orange. The sandstone is a well-sorted, medium to fine-grained quartz arenite that can contain mica. Large cross beds can be observed at the Black Hawk State Historical Site on the Rock River. Shales are very dark gray, laminated a lesser amount of olive gray shales are also present. The shale is associated with a number of localized coals. Two of the coals have been named in the lower part of the formation. The lowest is called Wildcat Den Coal bed, which is a black shaly coal that has pyrite, above this unit is the Wyoming Hill Coal Bed which is also shaly and pyritic. At the Allied Quarry, plant fossils in the shales occur at two intervals in a paleovalley. The plant remains represent "upland" floras in the lower zone which is a gray shale and typical lowland floras in the overlying black shales.Also occurring with the plant fossils in the lower gray shale is a fossil scorpion (*Labriscorpio alliedensis*). Locally at the base of this unit there have been reports of chert conglomerate. This formation is unconformable at the base and occurs in deeply cut paleo-valleys and paleo-karst features that occur in the Devonian units and Silurian units below.

D Sweetland Creek Formation Shale greenish to brown to dark gray, fissile, containing the spore *Tasmanites*. Top contact is unconformable with overlying Pennsylvanian rocks. The formation is poorly exposed and only observed as well cuttings. Just to the east in the Coal Valley Quadrangle a gray siltstone occurs in the shale that contains calcite veins with small amounts of sphalerite and galena. The base of this unit is unconformable with the underlying limestone.

E Cedar Valley Formation Limestone is yellowish gray brachiopod wackestones with solitary rugose corals and trilobites mainly phacopids. In the upper parts of this formation at the contact with Pennsylvanian the limestone can contain red stained argillaceous crinoidal wackestones and packstones. Greenish gray shaly beds are also present. The lower part of this limestone contains numerous fossils: colonial tabulate corals *Favosites* and colonial rugose corals *Hexagonaria*, brachiopods *Independatrypa*, *Pentamerella*, *Orthospirifer*, gastropods bellerophonids, platycerids, sponges stromatoporid mounds, *Astreospongia*, crinoids and blastoids. Occasional placoderm plates and bone fragments can be found. Bedding ranges from thin to massive. Basal bed disconformable with underlying unit.

F Wapsipinicon Formation Limestone is light gray to olive gray dense lime-mudstone, stromatolitic, brecciated beds; some beds are massive with rip-up clasts. This unit is characteristically unfossiliferous as opposed to the overlying limestone. A thin laminated pinkish-gray bed called "Milan Marker Bed" observed in the Mill Creek and Allied Quarries. The Pinicon Ridge Member is composed of various lithologies: argillaceous dolostone, green shale, chert and brecciated beds. A cave filled with Pennsylvanian strata was observed in the Allied Quarry at this formation level but has since been removed. Paleo-karst features like Pennsylvanian quartz arenites infilling sinkholes occur on Sylvan Island. At the Allied Quarry the basal rocks are composed of finely crystalline stylolitic limestone with abundant *Emanuella* brachiopods. There are more brecciated beds at base and the formation is unconformable with the underlying Silurian unit.

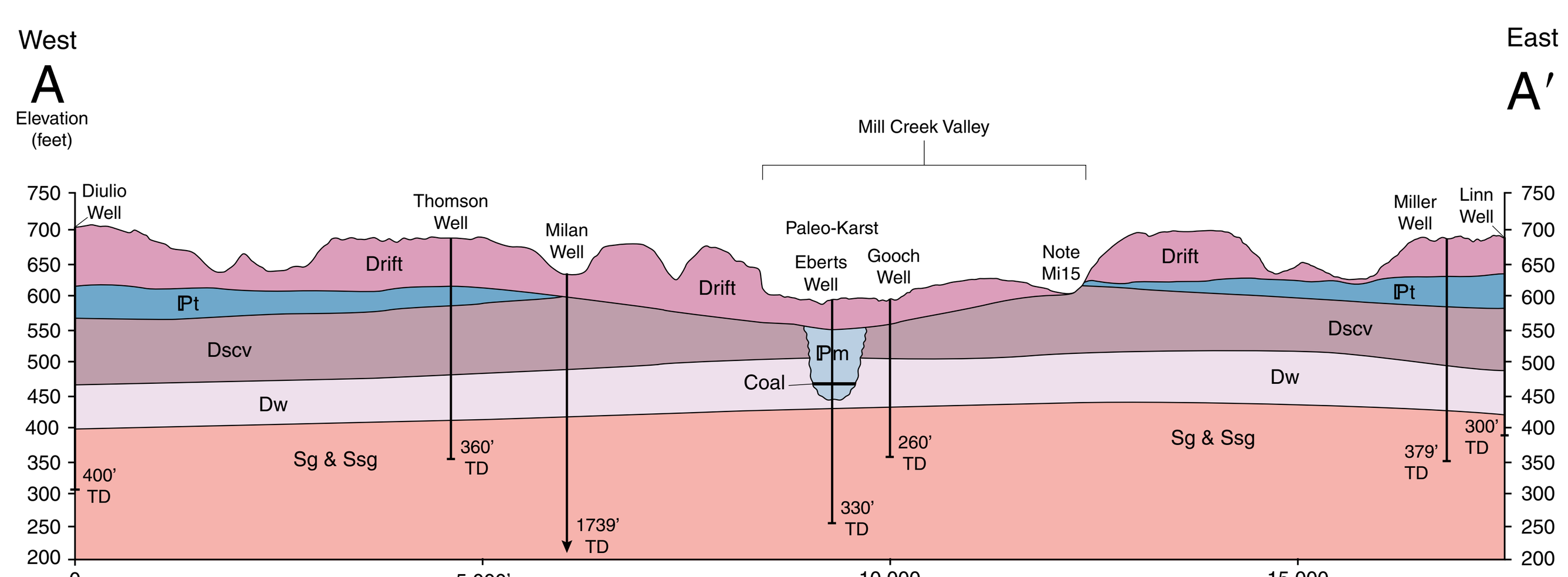
G Gower Formation Dolostone is gray-brown to yellowish-gray, dominated by framework or mound facies and fossil moldic wackestones seen at the bottom of both Milan and Allied Quarries. Fossils are common including: crinoids *Eucalyptocrinites*, *Siphonocrinus*, Cystoids *Caryocrinites*, *Megacystites*, corals *Favosites* and rugose corals, brachiopods, bryozoans, nautiloids, gastropods, and trilobites *Bumastus ioxus*, *Calymene niagarensis* and *Cheirurus*. The upper contact undulates through both quarries owing to paleo-karst cave and collapse structures. These rocks are high-quality, pure microcrystalline dolostone that is locally vuggy. Bedding is thick to massive irregular in places with the appearance of scattered reef debris. No lateral laminated facies observed in these quarries but these laminated facies have been observed in the Midway Stone Quarry to the east of the study area.

*Note: UD refers to Upper Devonian Series, and NA refers to New Albany Group

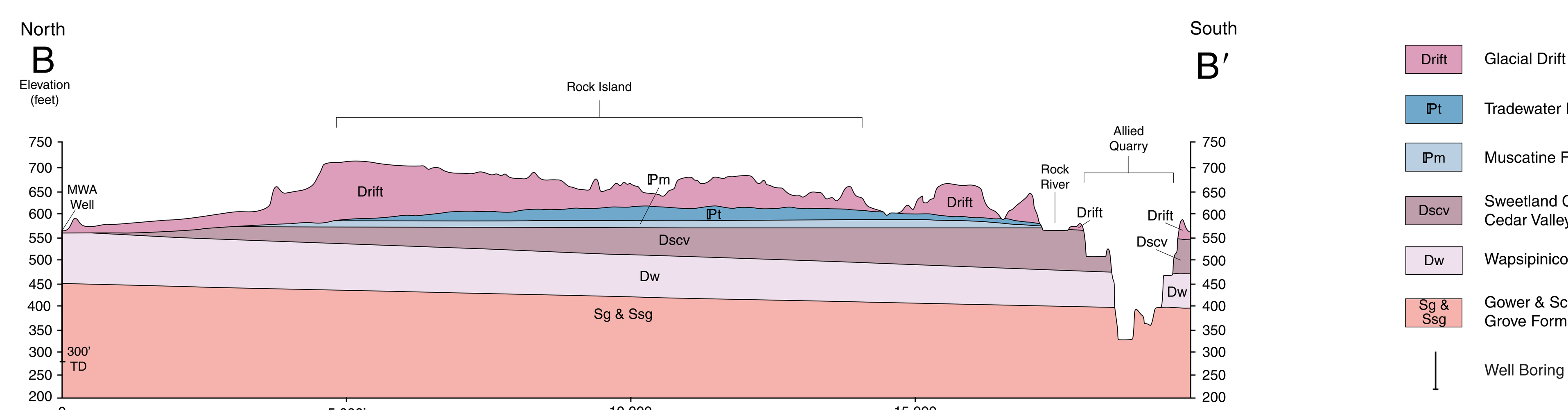
Geological features

Coal bed with burrows below

Plant fossils



Horizontal scale: 1 inch = 2,000 feet
Vertical scale: 1 inch = 250 feet
Vertical Exaggeration: 8×
Well labels indicate well name and total depth (TD) in feet.



Introduction

The Milan & Davenport East Quadrangles are situated in the Quad Cities area, Rock Island County, in northwestern Illinois. The Rock River runs east to west through the northern third of the Milan Quadrangle. North of the Rock River are the twin cities of Rock Island and Moline, Illinois. The confluence of the Rock and Mississippi Rivers is located in the northwestern corner of the Milan Quadrangle. Only the southern-most portion of the Davenport East Quadrangle occurs in Illinois and is divided by the Mississippi River which also runs east-west paralleling the Rock River to the south. The surface of both quadrangles are heavily mantled with loess and Illinoisan glacial drift. The Rock River is an under fit stream flowing into an earlier carved valley by the Mississippi River. This valley cuts into the Paleozoic bedrock between one and a half to two miles across. In Milan, bedrock exposures are poor but can be seen along the Rock River at Black Hawk State Historical Site and in north flowing tributaries to the Rock River. From east to west the drainages that have bedrock exposed include: Case, Mill, Sheldon, Kyte and Sand Creeks. In the southern part of the Milan Quadrangle glacial moraine deposits are thick and are composed of the Kellerville Till Member of the Glasford Formation. Glacial deposits were not mapped. Bedrock exposures occur in the Davenport East Quadrangle in one spot on the Augustana College campus west of the Roy J. Carver Physical Education Center. Other exposures occur at the Rock Island Arsenal and Sylvan Island on the Mississippi River. Most of the Illinois portion of the Davenport East Quadrangle is populated with urban and residential sprawl.

The oldest bedrock found in the study is the Gower Formation (Silurian, formerly called Racine in Illinois, see the section on nomenclatural changes in Illinois below). The Gower occurs at the lower part of the Mill Creek (Collinson Brothers) Quarry and at the Allied Quarry on Vandruff Island on the Rock River in the Milan Quadrangle. The oldest rock exposed on Rock Island Arsenal and Sylvan Island in the Davenport East Quadrangle is the Wapsipinicon Formation (lower Middle Devonian) see the stratigraphic chart on this map. The youngest Paleozoic rock exposed is the upper Tradewater Formation formerly called Spoon Formation (Upper Carboniferous, Middle Pennsylvanian). A broad structure called the Mississippi River Arch was first described by Howell (1935). This structural feature has a north by northeast trend affecting northeastern Missouri, northwestern Illinois and southeastern Iowa. It is widely accepted as the structural divide between the Illinois Basin and the Forest City Basin.

Methodology of creating the map

Numerous sources of data were used to develop the geologic map of the Milan and Illinois portion of the Davenport East quadrangles. The main source of information was plat verified wells from the Illinois State Geological Survey's water well database (ILWATER). Large parts of the study are covered with drift especially the southern third of the Milan Quadrangle. Archived field notes were also used: Richard Anderson, T.E. Savage, J. A. Udden, as well as past publications and field guides located below in the reference section. Sample sets of rock cuttings from some of the water wells were checked out of the ISGS core facility and studied.

The most important data set are the field notes that were obtained by traversing the rivers and the ravines of the study area during the 2019-2020 field season. The most challenging aspect of mapping this area was that every unit is separated by lacunas or major unconformities. After deposition of the Silurian the area was left topographically high. Late Silurian and Early Devonian strata are absent. Middle Devonian carbonates are known to be deposited in paleo-karst features and fractures within the Silurian. Then after Middle Devonian sediments were deposited the area was again left topographically high as seen by paleo-karst features in the Wapsipinicon and Cedar Valley limestones that are infilled later with Pennsylvanian (Morrowan) siliciclastics (Anderson 1998).

All of the glacial drift, alluvium and loess are omitted from the map.

Stratigraphic Units and Depositional Settings

Anamosa Member of the Gower Formation (Silurian) (see nomenclatural changes in Illinois below)
This formation takes its name from Gower Township, Cedar County, Iowa (Norton 1899) where there are quarried exposures of dolostone called "Anamosa Stone" (Anderson 1998). This facies of the Gower Formation is a yellowish-gray, distinctively laminated to crenulated dolostone known as the Anamosa Member of the Gower Formation. Shelly fossils are rare in the Anamosa Member and bioturbation is generally absent. Gypsiferous molds, laminated to crenulated dolostone and the lack of abundant invertebrates are thought to be due to the cut-off of circulation during deposition between broad biohermal mounds that created areas of evaporative sub-basins. This hypersaline condition may have been stratified in the deeper parts of the inter-mound area which led to the deposition of the Anamosa Member (Witzke 1994, Anderson 1998).

Although the Anamosa Member is a dominant facies of the Gower Formation its lateral equivalence, the Le Claire Member, is more prevalent in the Quad Cities area. The Le Claire Member of the Gower Formation contains a variety of facies from framework boundstones, packstones, wackestones to lime-mudstones (Witzke 1994).

Le Claire Member of the Gower Formation
This stratigraphic name originated with James Hall and J. D. Whitney (1858) where they described the "limestone of the rapids of Le Claire" Iowa, in the Quad Cities area. The Le Claire occurs in the lower part of the Mill Creek and Allied Quarries. It is a light gray to yellowish gray, vugular porous, fossiliferous dolostone. Fossils yield a highly abundant but low diversity brachiopod assemblage of rhynchonellid and athyrids along with tabulate and rugose corals. The most common fabric observed are fossil moldic wackestones. Pore spaces are lined with botryoidal fabric reflecting early acicular carbonate cements. Bedding ranges from steeply dipping to horizontal strata composed of fossil packstones, wackestones and lime-mudstones. This member has been interpreted as either mound, bank or reef facies that interfingers laterally with the laminated Anamosa Member. This member of the Gower contains shallow water, fossil framework mounds or "reef" build-up facies. This shallow water facies was subject to higher energy storm conditions, which resulted in a rubbly appearance owing to broken reef debris and subsequent cementation of the storm deposits. It typically has an overall massive appearance with crude, rough bedding which is aptly observed at the Allied Quarry.

The sub-Kaskaskia unconformity occurs in the area with the erosion or nondeposition of the upper Silurian and lower Devonian units. Some erosion is most likely as paleo-karst and fractures filled with Devonian rocks occurs in the Silurian units below.

Wapsipinicon Formation (Group in Iowa) (Lower Middle Devonian) (See stratigraphic column on map)
The Wapsipinicon Limestone was named for exposures along the Wapsipinicon River in southeast Iowa (Norton 1895). It is recognized in the Illinois Basin northwest of the Sangamon Arch where it thins to less than 20 feet (6 m). It is equivalent to the Grand Tower Limestone south of the Sangamon Arch. The Wapsipinicon unconformably overlies the Gower Formation in the study area. In the Mill Creek Quarry the Wapsipinicon is about 65 feet thick (20 m). This limestone is better developed in Iowa. The formation is divided into the Bertram Member (Formation in Iowa), Otis Member (Formation in Iowa) and Pinicon Ridge Member (Formation in Iowa). However, the Bertram in Illinois is only found in local channel fillings and fissures on the Silurian erosional surface. At the top of the Wapsipinicon Formation, a disconformity separates it from the overlying Cedar Valley (upper Middle Devonian). In the high wall of the Allied Quarry paleo-karst has been exposed in the past. These features are typically infilled with later Pennsylvanian siliciclastics. Barite crystals occur in these paleo-karst features within the Pinicon Ridge Member of the Wapsipicinicon Formation just across the river in the Linwood Mine near Davenport, Iowa. A small paleo-sinkhole infilled with Pennsylvanian sandstone occurs on Sylvan Island in the Davenport East Quadrangle.

Bertram and Otis Members (Formations in Iowa) of the Wapsipinicon Formation
At the Mill Creek Quarry just above the unconformity with the Silurian there are documented paleochannels and paleo-karst features that are infilled with reworked residuum, laminated, sandy, unfossiliferous dolostone of the Bertram (Formation in Iowa). In the Mill Creek Quarry the Bertram is poorly developed however, it is slightly better developed at the Allied Quarry on Vandruff and Carr Islands where it ranges from 0 to 6.5 feet (2m) thick. Bertram Member represent shallow water, arid coastal plain deposits initiated by sea-level rise.

Only the basal part 9.8 feet (3m) of the Otis (called Coggon Member in Iowa) occurs in the Mill Creek Quarry. At the Allied Quarry the Otis ranges from 18 feet (5.5m) to 23 feet (7m) thick. It is composed of recrystallized pelletal to skeletal packstones and grainstones. Poorly fossiliferous however, scattered molds of the brachiopod *Emanuella sublineata* can be locally abundant but well preserved in places. This member is a shallow water subtidal to intertidal carbonate platform facies.

Pinicon Ridge Member (Formation in Iowa) of the Wapsipinicon Formation
In Iowa the Pinicon Ridge Formation is divided into three members: Kenwood, Spring Grove and Davenport all of these facies are present at the Mill Creek and Allied quarries. In Illinois the base of the Pinicon Ridge Member (Kenwood facies) is dominated by unfossiliferous argillaceous dolostones, collapse breccias and laminated silt. The Spring Grove facies is a petroliferous laminated dolostone with collapse breccias. It contains stromatolites and disarticulated fish remains in the Quad Cities area (Anderson 1998). The Davenport facies is comprised of peloidal mudstones, very fine grained limestones and dolostones with collapse breccia beds. The Davenport facies of the Pinicon Ridge Member occurs on Arsenal and Sylvan Islands in the Davenport East Quadrangle. The Pinicon Ridge Member represents a time of shallow poor circulation resulting in high salinity conditions.

Cedar Valley Formation (Group in Iowa) (Upper Middle Devonian)
The Cedar Valley Limestone takes its name from the Cedar River in Iowa (McGee 1891). It overlies the Wapsipinicon Formation and contains only three members in Illinois: Solon, Rapid and Coralville (See stratigraphic column on this map). The Cedar Valley Limestone like the Wapsipinicon extends from the study area southeast to the Sangamon Arch. The most striking features seen in the Cedar Valley Formation are elongate channels filled with early Pennsylvanian sediments and fossils. These features were observed in both the Allied and Mill Creek quarries but have since been removed by quarry activity.

Solon Member (in Iowa Solon is a member of the Little Cedar Formation in the Cedar Valley Group)
The Solon Member disconformably overlies the Wapsipinicon in the study area. The lower beds of the Solon Member are grayish brown, sandy, argillaceous, fossiliferous wackestones and packstones. Locally grainstones also occur in the member. A diverse marine fauna including: brachiopods, disarticulated crinoids, trilobites and bryozoans are common. The most abundant brachiopod in the member is *Atrypa independensis*. A hardground is observed in the Mill Creek Quarry at the top of the Solon Member which is widespread in the area and in Iowa. The thickness ranges from 6 to 8 feet (1.8 to 2.4m) in the Mill Creek Quarry.

Rapid Member (in Iowa the Rapid is a member of the Little Cedar Formation in the Cedar Valley Group)
Above the hardground that occurs on the upper surface of the Solon Member is the Rapid Member. It is dominated by argillaceous, fossil, lime-mudstones and wackestones with local coquinoid lags. At one time the thickness of the Rapid Member was measured at 53 feet (16m) in the Mill Creek Quarry, (Willman et al. 1975). At the top of the Rapid Member is a burrowed discontinuity surface, that is not recognized in the quarries occurring in the Milan Quadrangle but does occur in the Quad Cities area in Iowa. It can also locally contain crinoidal-packstones that laterally grade into crinoidal wackestones in the upper part of the member. In the Milan Quadrangle, red stained crinoidal beds containing *Orthospirifer iowensis* were found near the northward bend of the Rock River on the north bank, just off State Highway 67. Here the Rapid Member is in contact with the Muscatine Formation (Caseyville). So along the north bank of the Rock River the overlying Coralville Member has been removed.

Coralville Member (Formation in Iowa)
In the Rock Island area the upper part of the Coralville Member rocks are different than any of the strata recognized in the Coralville Type area near Iowa City (Witzke, Bunker and Klapper 1985). It is composed of subtidal ramp facies called Cou Falls (Member of the Coralville Formation in Iowa). It is not known to occur in Illinois. However, it may be present in places within the subsurface. In general, the Cedar Valley Formation contains more normal marine facies that has biostromes of colonial rugose and tabulate corals and calcareous stromatoporid sponges along with numerous brachiopods and trilobites. Whereas, the Wapsipinicon has very little in the way of invertebrate fossils.

Sweetland Creek Shale (Upper Devonian)
A greenish gray shale and greenish siltstone that unconformably overlies the Cedar Valley Limestone is locally present. Thickness ranges from 0 to 44 feet (13.4 m) in the area. The Sweetland Creek Shale is known to contain conodonts. No exposures were observed in the quadrangles however, the unit was documented in cuttings and water well logs. It does not occur at the outcrop belt along the north bank of the Rock River at the Blackhawk State Historical Site. Here the Muscatine Formation (Caseyville) rests unconformably on the Cedar Valley Formation.

Racoon Creek Group (Lower and Middle Pennsylvanian)
The Raccoon Creek Group takes its name from Raccoon Creek Indiana named by Wier (1961). It is the basal group for Pennsylvanian strata in Illinois. It is comprised of Lower Pennsylvanian Muscatine Formation (new name) Morrowan Series ("Caseyville" Formation to be revised by Nelson et al. in progress) and the overlying Tradewater Formation (Atokan through Desmoinesian). These rocks occur in an erosional outlier in Muscatine and Scott Counties, Iowa and Mercer and Rock Island Counties, Illinois.

Muscatine Formation (New Name) (Lower Pennsylvanian, Morrowan) (see section on Nomenclatural problems with the lower Pennsylvanian "Caseyville" Formation in the Quad Cities Area)
Dominated by gray shales, siltstones and quartz arenites with thin localized coals. The Muscatine Formation (Caseyville) is a quartz arenite that is fine grained, well sorted, containing mica and is cross-bedded. It also has dark gray shale that rests unconformably on either Silurian Gower or Middle Devonian carbonates in the Milan and Davenport East quadrangles. A chert pebble to boulder conglomerate also locally occurs at the base of the "Pottsville" Muscatine Formation (Savage and Udden 1921). Fossils within the chert clasts were identified by Udden to be from Keokuk (Mississippian) and Silurian cherts (Savage and Udden 1921). A limonite crust from 2 inches (5.08 cm) to 2 feet (0.61 m) is also common at the contact with the Devonian limestone. Lithologies above the conglomerate vary from gray shale, silty shale, coal to interbedded sandstone and pure white quartz arenites. Rare quartz pebbles were reported by Savage and Udden (1921). The authors have not observed any quartz pebbles in the sandstone units. The Muscatine Formation (Caseyville) is confined to north-south trending paleo-valleys or random paleo-karst features in the study area. A photograph depicting an ancient karst feature showing a Devonian sinkhole coated with limonite and infilled with dark gray shale was taken by David White (Savage and Udden 1921). The location of the photo was taken near the south line of the NW¼, of section 13, T17N, R2W in the Milan Quadrangle which is now covered (p. 32 Savage and Udden 1921).

Two coal beds have been named in this formation the Wildcat Den Coal Bed and the younger Wyoming Hill Coal Bed in Iowa. At least seven coals in the "Caseyville" were recognized in Mercer and Rock Island by Searight and Smith (1969). The Muscatine ("Caseyville") locally gets up to 100 feet (30 m) thick in Mercer and Rock Island counties in Illinois (Pope 2012). This unit appears to be confined to a four county area Muscatine and Scott counties in Iowa and Rock Island and Mercer counties Illinois.

In the Allied Quarry the Muscatine Formation (Caseyville) occurs in channels and caves within the Cedar Valley Formation. Most of these paleo-karst features have been removed by quarry activity. However, the flora and fauna collected in these early Pennsylvanian shales have been documented by Richard Leary (Leary 1974, 1980a, 1980b). Fossils found from these strata are at the Illinois State Museum in Springfield, Illinois and at Augustana College Museum in Rock Island, Illinois.

The Muscatine Formation (Caseyville) was deposited in fluvial belts probably derived from the Canadian Shield or Wisconsin Highlands (Malone, personal communication). These rivers flowed west to southwest. Fossil plants found in channels at the Allied Quarry consisted of two separate floras. First, a diverse flora occurred in the lower gray mudstone of the channels. This lower flora is dominated by *Megalopteris*, *Lesleya* and *Cordaites* (Leary 1974). These types of fossil plants along with high diversity indicate an upland environment. Whereas, the second younger flora, found in the overlying black shale contained a lowland swamp flora. These plant fossils were a high abundance/low diversity flora containing only lycopods and *Mesocalamites* (Leary 1974). Further evidence of the terrestrial nature of these deposits is that numerous fragments of arthropods occur with the fossil plants. These include a fossil scorpion, *Labriscorpio alliedensis* and fresh water fish jaws and scales (Leary 1980a).

Core from the adjacent Andalusia Quadrangle drilled in the Linwood Quarry in Iowa have shown tidal rhythmite cycles which occur above the quartz-rich sandstones previously called "Caseyville". This shows marine influence mainly estuarine in the upper part of the Muscatine Formation (Caseyville) (Brian Witzke, personal communication).

Tradewater Formation
Both the Abbott and Spoon Formations have been formally changed in Illinois to the Tradewater Formation (Jacobson 1992). However, the Rock Island Coal is well represented in the Quad Cities area and forms the base of the Upper Tradewater Formation (Spoon). Where the Rock Island Coal pinches out it is difficult to differentiate Abbott from Spoon so the term Tradewater Formation has been used since 1992. The upper Tradewater Formation is dominated by siliciclastics, mainly gray to dark gray shales, siltstones and sublitharenites. It also contains minor amounts of calcareous shales, thin argillaceous, ferruginous, fossil wackestones, coal and bluish to white chert. The Seville Limestone occurs just above the Rock Island Coal and is exposed in Case Creek just off the study area in the Coal Valley Quadrangle. It is a dense, dark gray, argillaceous, lime-mudstone that occurs above the coal. Above the limestone is a medium gray shale that is overlain by a ferruginous, tan sandstone. Silty dark shales containing the ichnofossils: *Teichichnus*, *Asterosoma* and *Conostichus* were found higher in the formation in Mill Creek.

The environment of deposition of this formation varies from lowland swamps to estuarine deltaic settings.

Nomenclatural Changes to Silurian Stratigraphy in the Quad Cities area
Nomenclatural changes to Silurian stratigraphy in the Illinois Quad Cities area has been long overdue. The Gower Formation needs to replace Racine Formation in this area of Illinois. Savage (1926) introduced the term Port Byron for these rocks in northwestern Illinois. However, Port Byron was found to be equivalent to the Racine in the northeastern part of Illinois so, the name "Port Byron" was discontinued in Illinois (Willman 1943). Sutton (1935) was the first to use Racine Formation in the upper Mississippi Valley region. Racine was extended to include the entire sequence of reef-bearing rocks in the Chicago area (Willman 1943).

There are primarily three reasons why this change is needed. First, the rocks in this area of Illinois were deposited in the East-Central Iowa Basin and not in the Illinois Basin. Second, the depositional conditions were different in each basin, which led to lithological differences between member facies of the Gower Formation and that of the Racine Formation. The third reason is nomenclatural priority. The Gower Formation has been used for Silurian strata in the Quad Cities area since Norton introduced the term in 1899 (Witzke 1994).

There are lithologic differences between the inter-reef or intermound facies of the Gower Formation i.e. Anamosa Member and those inter-reef facies of the Racine Formation. The Anamosa Member is composed of unfossiliferous laminated to crenulated dolostone that are free of chert and shale. Whereas, the Racine inter-reef facies are commonly cherty, argillaceous and contain trilobites, crinoids and graptolites to varying degrees. Long-standing stratigraphic problems in this part of the Silurian are attributed to similar faunal composition seen in the mound facies and lithological characteristics between the Le Claire Member and the mound facies of the Racine Formation (Witzke 1994). The Anamosa Member does not occur in northeastern Illinois but does occur in places around the Quad Cities area. One such area is east in the Midway Quarry in the Port Byron Quadrangle. The presence of Anamosa Member in this western part of northern Illinois is different because it was deposited under hypersaline conditions whereas, this facies does not occur farther east. In the Chicago area, inter-reef deposits had normal salinities as seen by the abundant fauna. The stratigraphic term Gower Formation with its lateral facies the Anamosa Member and the Le Claire Member are used on this map. Revisions to ILSTRAT specific to the Quad Cities area will be forth coming.

Nomenclatural problems with the lower Pennsylvanian "Caseyville" Formation in the Quad Cities Area here in named the Muscatine Formation
The Caseyville Formation was originally named by David Dale Owen in 1856 in southwestern Union County Kentucky on the Ohio River. However, the type section was measured from outcrops on the Illinois side of the Ohio River between the mouth of the Saline River and Gentry's Landing below Battery Rock in Hardin County, Illinois (Lee 1916). A reference section for the Caseyville Formation was designated by Kosanke et al., (1960) along the Canadian National Railroad (formerly called the Illinois Central Gulf Railroad) in northwestern Pope County, Illinois.

Fitzgerald (1977) introduced the term "Caseyville" informally in his thesis for the area around Muscatine County, Iowa. Later the name Caseyville Formation was formally introduced to the Quad Cities area of Iowa by Ravn et al. (1984). The two main criteria that led Fitzgerald and Ravn to use the Illinois nomenclature was that they thought that these rocks were deposited in the East Interior Basin (Illinois Basin) and that they were both of Morrowan age. Another similarity is that these Morrowan sandstones are both quartz arenites in the Quad Cities and in southern Illinois.

The name "Caseyville" is inappropriate for usage in the area of Muscatine and Scott counties in Iowa and Mercer and Rock Island counties, Illinois. These rocks occur in an erosional outlier some 200 miles (321.9 km) northwest of the northern-most subcrop of the Caseyville Formation within the Illinois Basin. The Quad Cities area straddles the Mississippi River Arch between the Forest City Basin and the Illinois Basin. This area has been called the East Central Iowa Basin. Another major difference between these Morrowan rocks is sorting. The Morrowan sandstones of the Quad Cities area are well sorted whereas the sandstone units in the Caseyville of southern Illinois are typically poorly sorted. There also appears to be more mica content in the Morrowan sandstones of the Quad Cities. Another major difference is the presence of pebble sized, well rounded, milky white, quartz clasts in the Caseyville Formation of southern Illinois and no such pebbles have been observed in the quartz arenites of the Quad Cities. Provenance studies of the Caseyville Formation using detrital zircons show that the sands originated from the Appalachian Mountain region (Malone, personal communication). This also differs from detrital zircons sampled in the Milan Quadrangle at the Black Hawk Historical Site.

Geologists at the Illinois State Geological Survey plan to introduce a formal new name, Muscatine Formation after detailed study (Nelson et al. in progress). Muscatine Formation is named for the city of Muscatine, Iowa close to the Wyoming Hill roadcut, which provides a suitable type section. The authors have decided to use the term Muscatine Formation for these rocks on the Milan Quadrangle.

Economic Resources

Coal
The earliest mine in the study area producing coal was operating around 1886. It was located at the Black Hawk State Historical Site trail. At this particular site, the coal was confined to a sinkhole in the Cedar Valley Formation. The coal occurred approximately 80 feet below the surface in the Muscatine Formation. Ten coal mines were active in the past in the Milan Quadrangle. Most were shaft and slope mines that were mining the Rock Island Coal. Many of the mines were in the east central part of the Milan Quadrangle south of the Rock River. All are now abandoned. A larger number of coal mines were located farther east in the Coal Valley Quadrangle.

Limestone
Two limestone quarries are in operation in the Milan Quadrangle the River Stone Group Allied Quarry on Vandruff Island on the Rock River and the Mill Creek Quarry that was formerly known as the Collinson Brothers Quarry. Both operations quarry Devonian limestone and Silurian dolostone. The Mill Creek Quarry is located south of the Rock River in section 25, T17N, R2W near Mill Creek.

Groundwater
Potable water in the Milan Quadrangle is mainly sourced by wells drilled 80 to 570 feet deep in shallow bedrock. These wells source the Cedar Valley, Wapsipinicon, and Gower Formations (Bergstrom 1956). Waters from these carbonate systems have generally low concentration of dissolved solids, and moderate yields from 50 to 600 gallons per minute. The Village of Milan, Illinois sources the shallow bedrock with two wells, plus a third well withdrawing 90 to 530 gallons per minute from a deeper Cambrian-Ordovician aquifer. This is the only documented well sourcing groundwater deeper than 1000 feet in the quadrangle, indicated in cross section A-A'.

Cahokia Alluvium and colluvium infill most fluvial valleys across the region. In the Mississippi River and Rock River floodplains, coarser grained materials of the Henry Formation underlay and interleave with the Cahokia. These floodplain aquifers can yield more than 1000 gallons per minute, but they are generally unfavorable for potable supply due to high concentration of total dissolved solids. These surficial aquifers are best suited for industrial, agriculture, and livestock use.

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